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Photo electrochemically Manufactured HgO/Cu_2O Monolayer with Augmented Photovoltaic Features

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Abstract. *This writing report acquaint the chances for promoting efficiency betterment of p-Cu2O electrode for PECs likewise in production of hydrogen gas, using HgO/Cu2O hetero-structure. The arrangement was accomplished by both bracing the surface of p-Cu2O plate embattled through thermal oxidization of copper sheet and also acquiring low cost, effortless and low impairment engineering deposition for utilizing HgO as absorber layer. The altitudinous efficiency of 4.80% and open circuit voltage of 185MV were incurred in an HgO/Cu2O hetero-structure PEC solar cell commence with copper foil thickness (0.1mm) substrate for preparing the Cu2O thin film under oxygen gas pressure at 950℃ by thermal oxidizing techniques. It is requisite to augmented the interface at the hetero-structure junction to accomplished a soaring efficiency in HgO/Cu2O/HgO semiconductor beside multiplicative the parallel resistance and remittent the series resistance.*

Keywords: thermal oxidation; cuprous oxide; hetero-structure; J-V characteristic, photoelectrochemical, annealing, etching

1. Introduction

Sustainable rootage of energy for gleaning solar energy has for all time been a development subject field of interest, with greater than before focus in the research of hydrogen gas by photo electrochemically water-splitting at the photo cathodes [1] and p-type semiconducting material that can change over solar irradiation into electrical energy in photovoltaic cells[2,3]. The photovoltaic transition method is consisted of 3 three sequential steps: exhilaration of valency band by the negatron to conduction band by light assimilation when ray of light by photon free energies bigger than the band gap vigor of the photoactive stratum, as a consequence of the absorption yielding to establishment of excitations consisting of hole-electron pairs; disassociation of the excitations to emancipated carriers; and the carrying of carriers by the electrical field created at the hetero-interface[4,5]. Therefore, the transition efficiency for solitary p-n-heterojunction photovoltaic cells is intimately connected to the band gap free energy of the p-semiconducting material, and the hypothetical transition efficiency is anticipated to be roughly 28% under the situation of being uncovered to solar radiation of AM1.5 illumination (1 sun) [6].

To further the enlargement of the light-soaking up band, enhancing the transition efficiency, and improvement of quantum transition efficiency are compulsory, and it is promising strategy for acquainting two or more p-type semiconductors materials with dissimilar band gap free energies in a light engrossing stratum to get the better of the restriction of band gap free energy-originated hypothetical transition efficiency imposed on solitary photovoltaic cells[7], transition efficiency of

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33.7% incontestable by a InGaP/GaAs/InGaAs threefold-junction tandem photovoltaic cell [8] Copper I oxide (CuO)[10] and Copper II oxides (Cu_2O)[9] are p-type semiconductors materials with the band gap free energies of 1.4 and 2.1eV, and both of them have the quality of being utilize as photovoltaic layers in oxide photovoltaic cells,[11-12] likewise as photocathode's and to fabricate hydrogen natural gas by photoelectrochemical water ripping [13-14] in addition, p-Cu_2O/pCuO monolayer live up to the aforesaid multi-band gap scheme to improve the performance and attracted escalating attention as photoactive stratums [15-17]. Thermal oxidization of metallic copper foil had been embattled the Cu_2O and CuO layers by abundant techniques [18,19] gas-stage deposition procedures such as pulsed laser deposition and sputtering [20,21] and solution compound procedures which comprise of electrochemical procedures [22-23]. The Cu_2O/CuO monolayer have been embattled by numerous ways equanimous of chemical arrangements complied by heating system [24,25], and the enhanced photovoltaic and a cathode that emits electrons when well-lighted features have incontestable for those organized by the Cu_2O electro-deposition complied by concomitant thermal oxidization in air.[15,16] The Cu_2O/CuO monolayer's displayed an extend solar cell wavelength compass uprising from both CuO and Cu_2O stratums, but the exterior quantum efficiency (EQE) was low down, equated to those for the solitary CuO and Cu_2O stratums [26,27]. The unveiling of nanopores into the Copper II oxide stratum and morphological modifying in the texture of the CuO stratum were conveyed onward by heating system, which pose damaging effects on the solar cell feature [15].

Here, we account the manufacture of HgO/Cu_2O monolayer's by two subsequent thermally oxidizing methods; For synthesis of Cu_2O from Cu plate followed by annealing technique of Cu_2O layer in a furnace under vigorous oxygen condition, while for deposition of HgO was also deposited using thermally oxidizing method, the effect of HgO/Cu_2O stratum structure, optical and photovoltaic were investigated using FTIR and I-V characteristic curves.

2.THEORETICAL CONSIDERATION

A photoelectrochemical (PEC) photovoltaic cell which occurred in both p-type and n-type semiconducting materials which composed of operational electrode and counter electrode; for p-type semiconducting material is composed of operational electrode which is cathode and the anode as the counter electrode, while in the case of n-type semiconductor electrodes will constitute the anode as the operational electrode and a cathode as a counter electrode. The two different electrodes are interrelated through an outer circuit. Where between the electrodes a liquidness electrolytes is rendered to the photovoltaic cell, serving as a conducting intermediary. The operational electrode can be constituted of a semiconducting material, nanocrystalline or polycrystalline, which is usually affiliated to a conducting substratum.

Electric current will flow as soon as electrolyte brought into contact with an n-doped semiconducting material, and their equilibrium is earned when their electrochemical potentialities are equated. Shut to the semiconducting material electrolyte boundary or interface the assimilation of a quantum of electromagnetic emanation with free energy exceptional the banding gaps bring forth hole-electron pairs. In instance of the touchstone redox potential (Voredox) lies below Fermi level (EF), the electrons will be reclusively from the semiconducting material to the electrolyte, leave-taking positive charges at the rear. When the holes reach out the surface and respond with a solution that comport electricity, charge dismemberment will take placed. The majority of the semiconducting material and prospective drop incurred amongst the surfaces

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produce an electrical field, were disseminated in a charge polarized grade-constructed stratum (space charge layer) and represented by an alleged band bending, see Figure 1 concerning the disengagement method of the photo yielded hole/electron pairs the electric field is significant. In the solution that convey electricity the charge ordering is frequently delineated in the terms of Gouy-Chapman layers and Helmholtz [28],

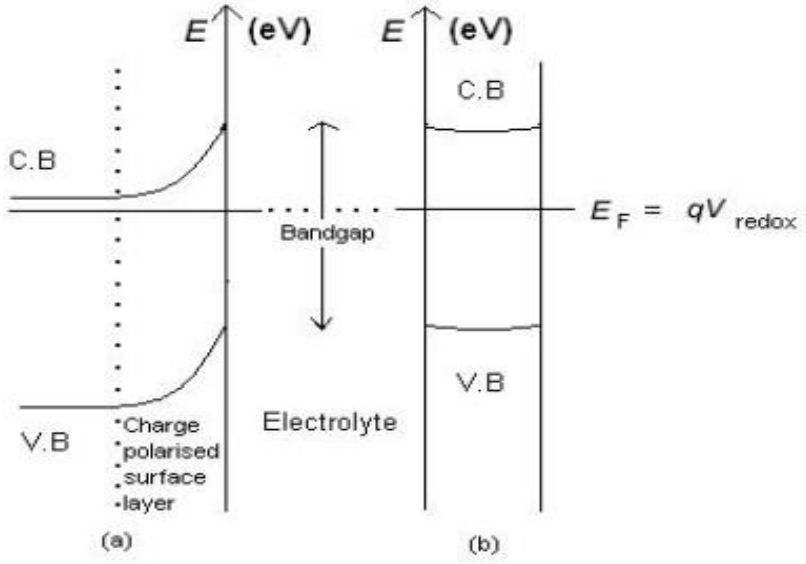

Figure 1. Graphical representation arrangement of a charge-polarized facade layer in PECs photovoltaic cell[29]

3.EXPERIMENTAL PROCEDURE

Thermally oxidizing technique was pick out to produce the copper II oxide thin film and HgO/Cu_2O hetero-structure. The working electrode was a piece of HgO/Cu_2O plate and the counter electrode was a piece of copper foil plate. The electrolyte comprised of 1g of NaCl in 1 ml of sublimate water in a crystal clear cylinder.

Copper plate in sort of foil thickness 0.1mm after wounding into standard size wafers of 2cm×2cm were thermally oxidizing in a furnace, engraving in a washy nitric acid HNO_3, mantled up with paper for the purpose of smoothened the surface of the foil with aid of edge of beaker or bottle and finally dried with oven at 40-50℃ and hive away in a scavenge envelop prepared for soaring temperature oxidization.

The sample was place in between ceramic crucible and placed inside a soaring temperature furnace at 950℃ which oxidized for 8 min and right away quenched in cold distilled water then dried by inserting them in between papers tissue then last but not least in air. Annealing process was conducted in order to cure defect in the sample after the long temperature oxidization which carried at 500℃ inside the furnace quenched in sublimate water then finally in air followed by

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chemical engraving process which was conducted in order to removed the unwanted black copper surface on top of the livered cuprous oxide using 4gm of $FeCl_2$, 4gm of NaCl all in 100ml of sublimate water which act as the solvent, 2ml of HCl concentrated then the model was engrossed in all mention solvent shaken gently until the black colour completely engraved then dried in between tissue paper as a final point in air. Another engraving in 8gm of potassium persulphate dissolved in 100ml of sublimate water, the appearing of livered colour feature of Cu_2O considered the complete engraving processes (see Figure 2).

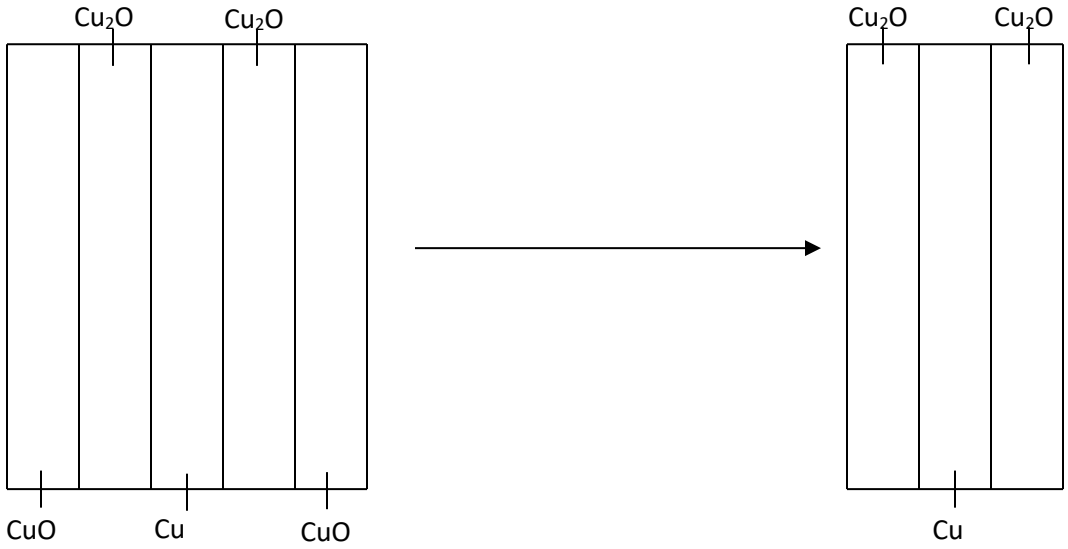

Figure 2. Block illustration of the engraving process

After the synthesis of the Cu_2O via the unalterable etching process we used the chemical vapour transport (CVT) figure 3 consist the mixed mercury oxide with transport agent (Bromine Br) in a given container were the oxygen inside the furnace as the Chalcogen within an unseal vacuum. The unseal vacuum was placed in the clayware crucible and then arranged in a higher temperature furnace (700-1000℃), were a dynamical force within the unseal tube produced temperature gradient which help or excited the transport agent which lead to the deposition of HgO on the Cu_2O.

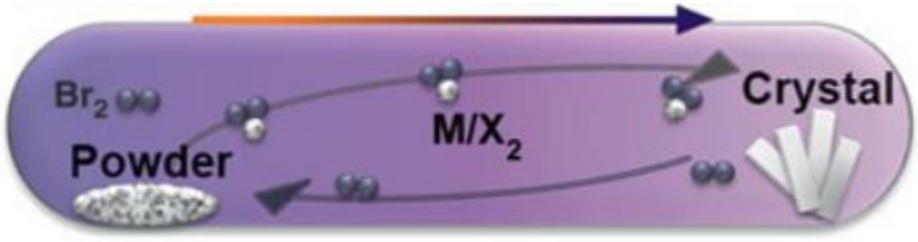

Figure 3. Chemical vapour transport [29]

Testing the solar cell was conducted in a transparent container containing 1 mole of the electrolyte (NaCl) copper wire electrode were made to the two electrode the working electrode (HgO/Cu_2O)

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and for the counter electrode (Cu) using ash grey paste and subsequently both placed within the container then to micro-ammeter for the rationale of perusing the I-V characteristic as demonstrated below in Figure 4.

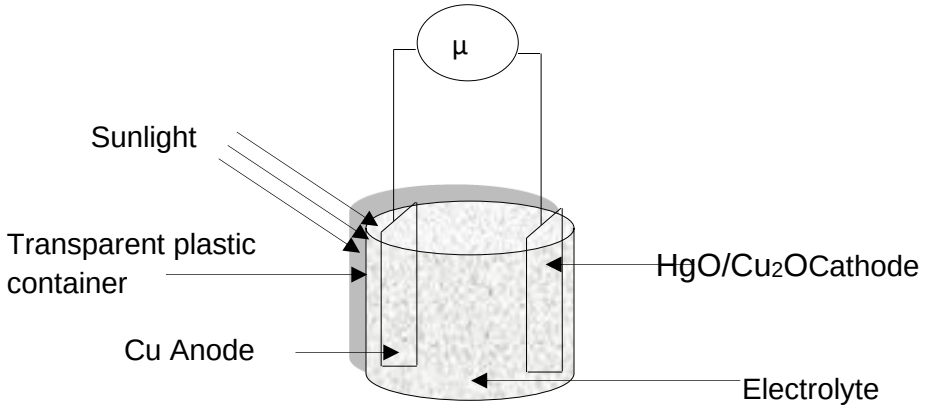

Figure 4. Diagram of the made-up HgO/Cu_2O Photoelectrochemical solar cell

4.RESULT AND DISCUSSION

Photo electrochemically manufactured HgO/Cu_2O monolayer's and the solar cell features; figure 5 and 6 shows the curved thermally oxidizing HgO/Cu_2O and Cu_2O layers under the illumination which conduced to the deduction of photovoltaic parameters in table 1.0 below. As seen here the deposition of the HgO on the Cu_2O substrate drastic increase in the external solar cell parameters under illumination the efficiency increase from 0.474% to4.799% likewise the short circuit current with all other parameters are also been affected by the deposition. Because light with photon free energies larger than the band gap free energy of HgO/Cu_2O layer constitute a considerably large portion of the sunlight induced the absorption of free energy and consequently cause excitation of electrons from the valence to conduction band in the HgO/Cu_2O layer which were then swept toward the solution by the electric field formed at the boundaries between the HgO/Cu_2O layer and the electrolyte solution. The increase in electric current and the voltage originated from the increase in minority carries of electrons within the electric circuit of HgO/Cu_2O-Cu fabricated photovoltaic cell and the electrolyte.

Table 1. The photo voltage, efficiency, maximum power, and photocurrent of different readings of Cu-HgO/Cu_2O photoelectrochemical solar cell

S/N	I_{SC}	V_{OC}	P_{MAX}	η
1	0.89mA	28mV	14.6×10^{-4}W	0.474%
2	3.28mA	185mV	153×10^{-4}W	4.799%

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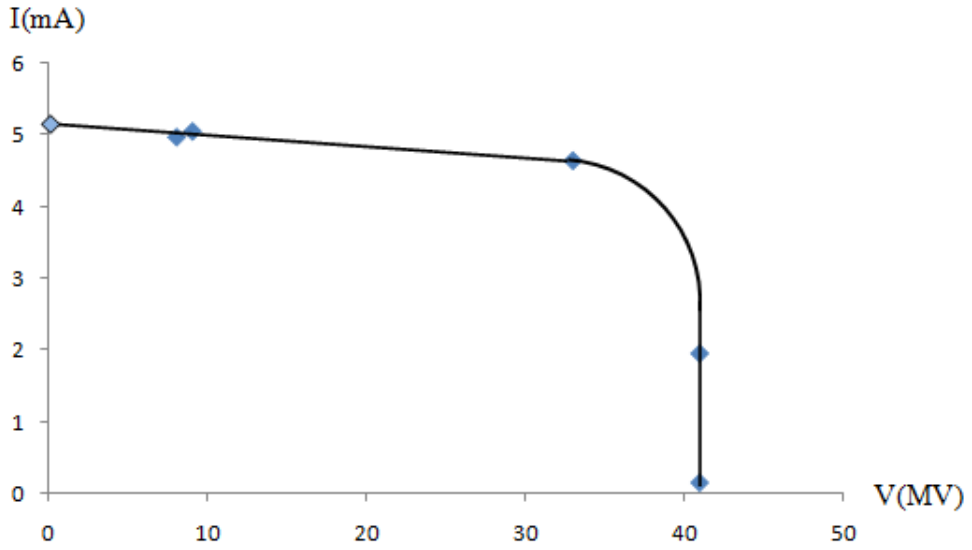

Figure 5. The current-voltage features of synthesized Cu_2O before deposition HgO

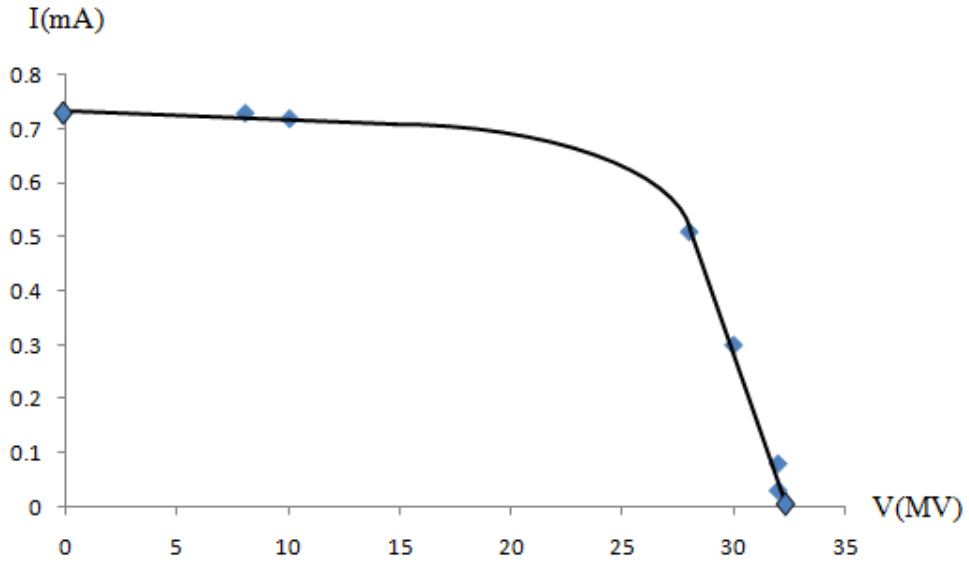

Figure 6. The graph of current-voltage features of synthesized HgO/Cu_2O/HgO after deposition of HgO

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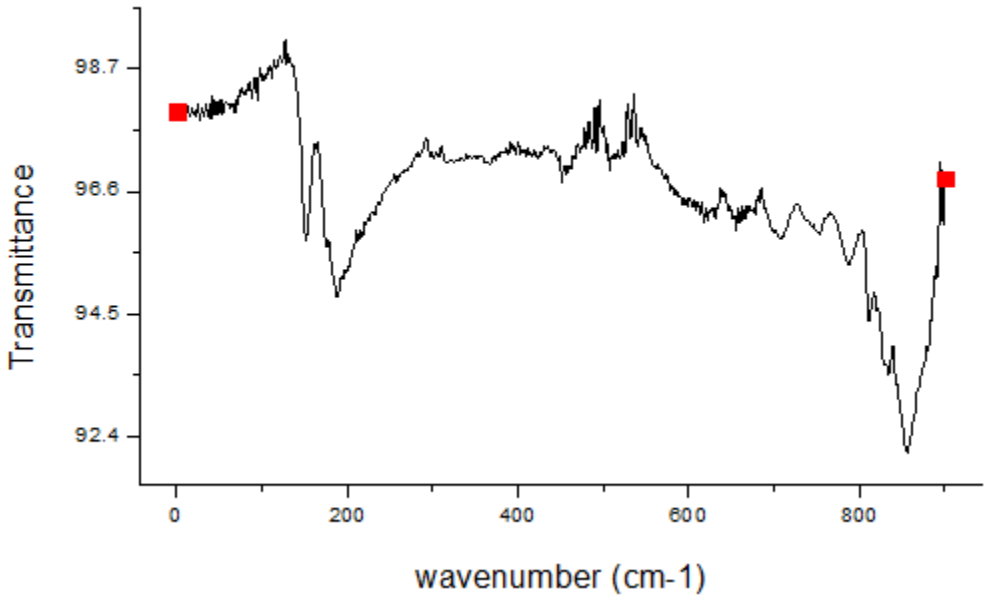

Figure 7. The FTIR of Deposited Mercury oxide in a furnace on pinnacle of Cu_2O substrate

Figure 7.0 present the psychoanalysis of HgO/Cu_2O FTIR. In the sample there are five 5 different huge peaks with more than 10 different small peaks detected or perceived from the sample when examining, expressing that the sample is not a simple structure but a complex structure; meaning that the deposited HgO stratum conjointly with the substrate Cu_2O composed of antithetical parts which are also tricky in examining them independently. Appearance of some extremum at the single bond area notifying that there is single bond inside the model. Disappearance of broad absorption band were hydrogen bond is located explicated that there is no hydrogen bond, visual aspect of sharp band in oxygen-related compound inside the examined model, wholesome the present of the Cu_2O substrate in the model. Correspondingly Hydroxyl compound extremum was also perceived at the range of substantiation of Hydroxyl compound. No aromatic structure detected in the sample but there is C-C bond perceived at the model. Also aldehyde extremum was found immediately after the aromatic peak boundary. No triple bond region in the sample responding to absence of C≡C triple bond. Vinyl related compound accessible at the sample surface. No aromatic ring compound detected. A finger print region which is always discovered at the tail end or fag end of the FTIR graph was also perceived were the whole nature and structure of the model are present.

4. Conclusions

Soaring-efficiency p-type semiconducting material hetero-structure photovoltaic cells were manufactured by machinating HgO/Cu_2O/HgO thin film on Cu_2O sheet that had been organized by thermal oxidizing of copper foil sheet. The momentous betterment of photovoltaic belongings was accomplished by not merely bracing the surface of p-Cu_2O plate embattled through thermal oxidization of copper II oxide but also acquiring low cost, effortless and low impairment engineering deposition for utilizing HgO as absorber. The procurable photovoltaic belongings in

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HgO/Cu_2O/HgO semiconducting material hetero-structure solar cell are substantially more stage-struck by the experiment condition of the boundary at the hetero-structure. The soaring efficiency of 4.80% and open circuit voltage of 185MV were incurred in an HgO/Cu_2O-Cu manufactured solar cell from the initial foil of thickness 0.1mm by two thermally oxidizing methods for preparing Cu_2O and for deposition of HgO on Cu_2O and quantitate under solar illumination.

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